Accuracy of the Acetabular Index Using the Percutaneous Assisted Total Hip Technique

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Abstract

In minimally invasive total hip arthroplasty (THA), proper acetabular component positioning can be difficult to achieve without navigational or intraoperative radiographic methods. Acetabular components placed in excessive abduction can lead to early failure and dislocation.

This article describes a series of 74 consecutive primary THAs (71 patients, 3 bilateral) performed using a percutaneous assisted THA technique that does not require navigation, yet allows adequate visualization for accurate acetabular cup placement. No patients were excluded (because of body mass index or abnormal anatomy) from the study.

Mean abduction angle for all hips was 45°. The goal was acetabular abduction angle between 35° and 55°. This goal was achieved in 72 of the 74 hips (97.3%).

Proper acetabular abduction angle can be achieved in the majority of cases using this new soft-tissue sparing approach for THA.

Minimally invasive surgery (MIS) has been embraced enthusiastically by the general population and is an option offered by 80% of Hip Society surgeons.[1] The ability to undergo total hip arthroplasty (THA) with less postoperative pain and more rapid recovery is especially appealing to the next generation of joint replacement patients. Whether these ambitious outcomes are achieved with smaller incisions is still being debated, but it is intuitive that a small incision limits soft-tissue damage, yet must be large enough to ensure accurate visualization.[2-4]

One potential problem with less invasive THA is the possibility for malpositioning of either or both components. Component malpositioning is an important factor that influences the incidence of impingement, dislocation, polyethylene wear, and aseptic loosening of the hip prosthesis.[5-8] Difficulty in achieving an optimal position for the acetabular reamer and the acetabular implant may result from inadequate visualization of the operative field.

The Percutaneous Assisted Total Hip (PATH) technique (Wright Medical Technology, Arlington, Tennessee) was developed in an effort to assist surgeons in optimizing acetabular positioning with less exposure. This technique eliminates the angular constraints of typical MIS approaches. It was designed to assist surgeons in attempting to achieve consistent acetabular inclination with minimal soft-tissue disruption without the need for computer-assisted navigation. To evaluate the results of this technique, 74 consecutive primary THA cases were reviewed and the acetabular inclination angles radiographically evaluated.

Methods

Surgical Technique

The PATH technique was used in all cases. This technique attempts to reduce the trauma and incision length in THA. It consists of a small posterior approach to the femur and a percutaneous approach for the acetabular reaming.

The patient is placed in the lateral decubitus position. In contrast to traditional THA patients, PATH patients are moved as far forward and anterior on the table as possible. This permits maximum adduction of the

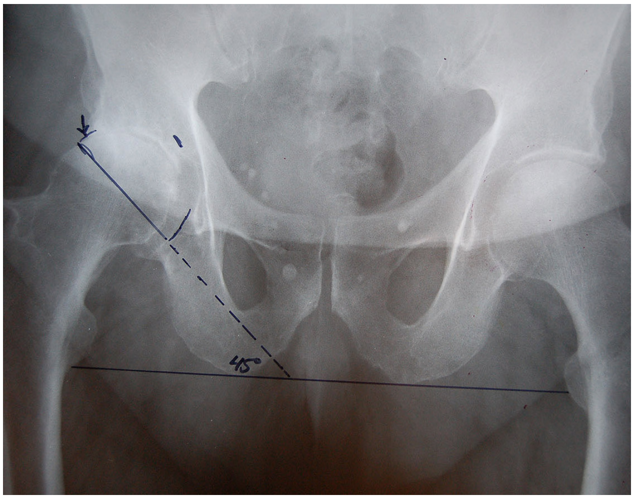

Figure 1. Preoperative radiograph shows correct position of cup. With cup placed in 45° of abduction, approximately 8 mm of cup rim should be visible protruding from edge of acetabulum (arrow).

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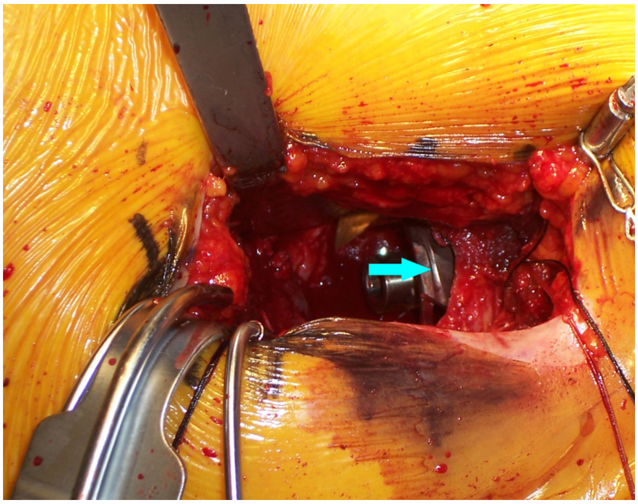

Figure 2. Trial cup placed in acetabulum. Desired 8 mm of trial cup (arrow) is visible.

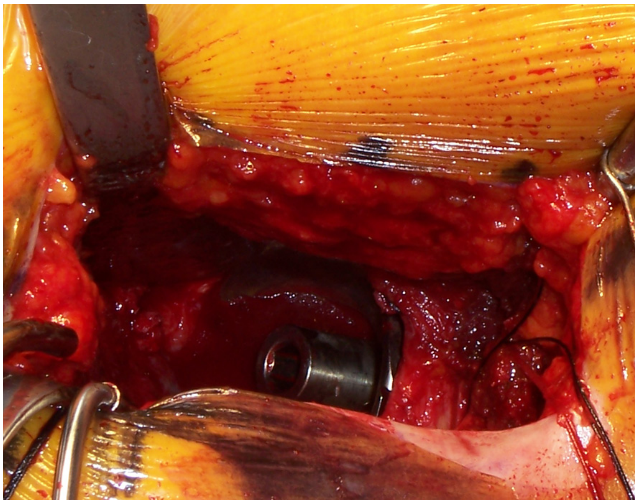

Figure 3. Cup placed in this position would be in excessive abduction.

operated extremity, permitting enhanced exposure over the posterior skin edge during femoral preparation and component insertion.

Femoral Preparation. The femur is prepared first in order to obtain information about femoral anteversion. This information is used with cup anteversion information to obtain combined (femoral plus acetabulum) anteversion of approximately 30°. After the femoral canal is hand-reamed, the real prosthesis is impacted (if a modular femoral component is used), and attention is directed to the acetabulum.

Retractor Positioning for Acetabular Exposure. The leg is positioned in approximately 30° flexion, 0° adduction, and 30° internal rotation. Complete muscle relaxation is very beneficial at this stage of the procedure. The anterior acetabular retractor is placed along the anterior acetabular rim, distal to the anterior inferior spine at approximately 10 o'clock to 11 o'clock for the left hip and approximately 1 o'clock to 2 o'clock for the right hip. It is secured just over the bony rim and should not lever on the gluteus muscle but on the tip of the greater trochanter (tilting approximately 30° toward the foot of the patient). This retractor may require adjustment during the operation. A narrow Hohmann retractor is placed at the 12 o'clock position above the labrum and just inside the capsule. A small amount of dissection performed with a bovie or curved half-inch osteotome facilitates separation of the labrum and the capsule. This provides a shelf for placement of a 1/8-in Steinmann pin or, preferably, a Charnley spike. The pin or spike is placed above the lateral rim of the acetabulum but is directed proximally to avoid interference during reaming.

The next acetabular retractor is placed posteriorly on the ischium, between the capsule and the labrum. Extending the hip at this point relaxes the posterior soft tissues and aids in retractor placement. The retractor is fixed into position using 1/8-in Steinmann pins, which retract the posterior-inferior capsule and facilitate posterior rim exposure. Soft tissue is cleared from within the acetabulum and complete labrectomy is performed. The entire acetabular rim and appropriate bony landmarks should be visible with the retractor array as described.

Portal Placement for Acetabular Preparation. After proper retraction has been achieved, medial reaming is initiated. A reamer, 5 to 7 sizes smaller than the templated cup, is used at the start, and the acetabulum is prepared with progressive medial reaming until the acetabular floor is reached. A small acetabular trial shell or face plate is then selected and attached to the acetabular alignment handle using the threaded cup adaptor and the portal placement guide. The trial shell, usually 3 to 4 sizes smaller than the template, is lowered into the open acetabulum. The alignment handle indicates the desired final cup position and helps position the portal placement guide. The alignment shaft handle is placed perpendicular to the table in an attempt to produce an acetabular angle of 45° (Figure 1). Additional adduction is sometimes required, as the pelvis may have been tilted as much as 15° anteriorly secondary to the femoral retraction during the femoral reaming. Preoperative templating assists acetabular component positioning by predicting component uncovering. When too much of the superior lip of the shell shows, final cup placement may be too horizontal; when too little shows, the cup may be too vertical. Figure 2 shows the reamer with too much abduction; when reamed and positioned in this way, the cup would be placed too horizontal. Figure 3 shows the reamer in good position, which would allow reaming and cup placement at a 45° angle. Anteversion would vary according to femur version, but, with the crossbar portion of the handle perpendicular to the patient's torso, anteversion is approximately 20°.

Table. Inclination Angle (IA) by Body Mass Index (BMI) Group[a]

	BMI (kg/m^2) Group				
IA Statistic	Normal (18.5-24.9)	Overweight (25-29.9)	Obese (30-39.9)	Morbidly Obese (>40)	Total
n	14	20	26	7	67
Mean	46.1	44.5	44.8	46.4	45.2
SD	6.1	6.3	6.7	5.6	6.1
q1	42	40	40	43	40
Median	46.5	44	44	46	45.5
q3	50	49	50	51	50
Minimum	35	35	30	38	30
Maximum	55	59	55	55	59

[a]Kruskal-Wallis test for equal angle among BMI groups, $P = .762$.

Trocar/Cannula Insertion. The trocar is first placed through the cannula and then through the portal placement guide sleeve in order to create the portal just behind the posterior edge of the femur. An approximate 1- to 1.5-cm stab wound is made where the trocar will intersect the leg. The trocar and cannula are passed through the stab wound, with the cannula remaining behind after the alignment handle/portal placement guide assembly is removed. Cannula is posterior to femur.

Acetabular Reaming. The hex socket reamer baskets are passed through the main incision while the reamer shaft is passed through the cannula. Reaming starts 3 to 4 sizes under the templated acetabular size. The stationary cannula allows for consistent and reproducible reaming, which should produce more precise cup fitting. The acetabular component is placed on the alignment handle, passed through the main incision, and located in its appropriate position within the acetabulum.

Acetabular Cup Placement. The acetabular component is introduced in line with the incision. The PATH incision allows for excellent visualization of the reaming and subsequent cup placement. Component placement is performed using the alignment guide as both a cup holder and an alignment indicator (Figure 4). The acetabular component is impacted in approximately 45° of abduction and in a combined femoral/acetabular anteversion of 30° to 35° using the alignment guide, bony landmarks, and an understanding of the true patient position at the time of cup placement. If there has been a shift in pelvic orientation secondary to femoral preparation or acetabular retraction, then there will be discrepancies between the final reamer and preoperative templating. Changes in cup version can then be made accordingly, with anatomical orientation taking precedence. Figure 5 shows the final position of the cup.

Radiographic Assessment

An independent radiology group evaluated the radiographs. A horizontal line was drawn beneath the transischial lines. Another line was drawn across the face of the acetabular component that incorporated both the superior and inferior aspects of the acetabulum. Intersection of these 2 lines determined acetabular inclination.

Statistical Analysis

Postoperative angles were analyzed with the Kruskal-Wallis test. Three patients had bilateral THAs, and their angles were included as 6 independent observations.

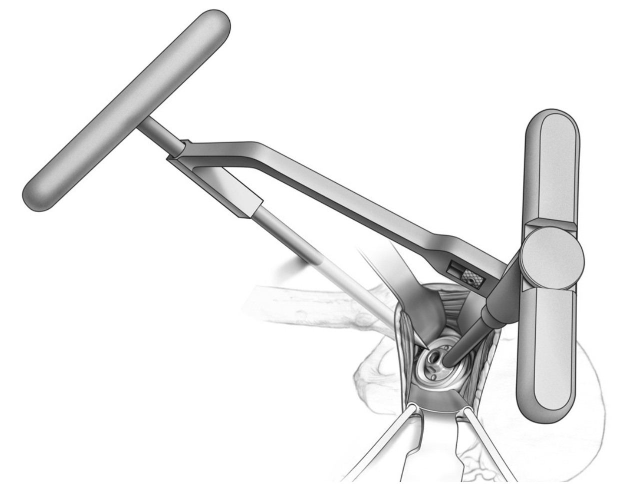

Figure 4. Drawing shows how this would look with positioner in place.

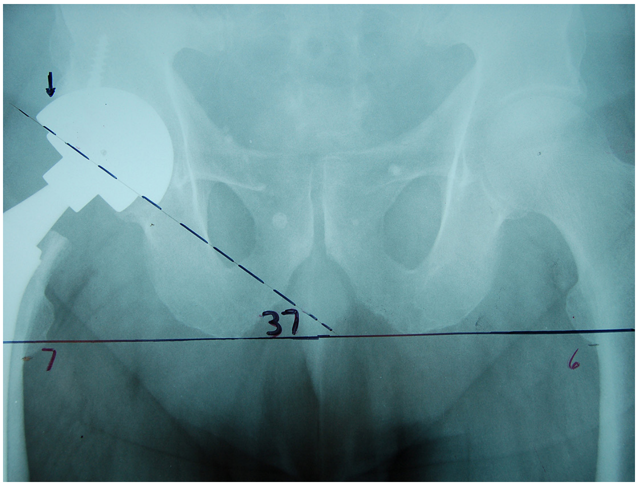

Figure 5. Postoperative radiograph shows good position of cup with 40° of abduction. Outliers were 59° and 30°.

Results

Seventy-four consecutive primary THAs were performed in 71 patients (36 men, 35 women) over a 1-year period. Mean age was 67.7 years (range, 45-92 years). All THAs were primary and there were 3 bilateral procedures. Mean body mass index (BMI) was 31.3 kg/m^2 (range, 20.9-73 kg/m^2) for 67 patients (BMI data were not recorded for 4 patients). Forty percent of the patients were obese and 10% were morbidly obese. No patients were excluded (because of BMI or abnormal anatomy) from the study. This series represents my first 74 uses of this new soft-tissue sparing approach.

Follow-up ranged from 5 months to 18 months. There were no dislocations, subluxations, or revisions. There were no intraoperative complications and 1 postoperative complication (nerve palsy, partially resolved). Mean abduction angle for all hips was 45°. The Table lists the inclination angles by the BMI categories. Statistical analysis found no difference in angle according to BMI category (P = .7620).

Discussion

Acetabular component malpositioning is probably the most important factor in limiting dislocation. Proper placement can also limit component wear.[6-8] It is therefore essential that the surgeon choose an approach that allows for comfortable and accurate insertion of the acetabular component.

MIS was developed to lessen pain and speed postoperative recovery. Use of MIS techniques, however, adds new difficulties in accurate cup orientation. The risks of MIS will outweigh the benefits if the technical challenges adversely affect the long-term results of an otherwise predictable procedure such as THA.

Presently, arguments against MIS are based on the assumption that poor visualization leads to component malpositioning. Multiple studies have identified risks associated with MIS.[9-11] Pagnano and colleagues[9] found that MIS leads to an increase in socket malpositioning, intraoperative femoral fractures, wound complications, and dislocations. The same findings were reported by Bal and colleagues,[10] and Teet and colleagues.[11]

Acetabular component malpositioning is a recognized problem in THA. Mechanical alignment guides have had varying degrees of success. Bosker and colleagues[12] noted that freehand placement of the acetabular component is not a reliable method. Use of guides as the sole source of alignment can therefore lead to a discrepancy in desired outcomes. Woolson and colleagues[4] found that 15% of the acetabular components were outside the safe zone with use of a standard incision, and 30% were outside the safe zone with use of a mini-incision. They postulated that the limited visualization of the acetabulum resulting with use of the small incision was the likely factor in the poor radiographic results.[4] Computer-assisted cup positioning has been proposed as a method for addressing this problem. Najarian and colleagues[13] reported 13.2% outliers with use of a mechanical guide in a posterior approach. Their accuracy improved to only 4% outliers when navigation was added. Wixon and MacDonald[14] found that conventional cup placement in a mini-posterior approach resulted in 20% of their acetabular components being outside the safe zone. Their accuracy also improved significantly, to 5% outliers, with use of navigation. The results of these studies suggest that freehand placement is not reliable and that mini-incision with the freehand technique is the worst of both worlds.

The PATH technique is a soft-tissue sparing approach that can provide safe and reproducible outcomes through use of a percutaneous guide that comfortably positions the acetabular component in a safe zone. The excellent acetabular visualization afforded by this technique allows surgeons to use the alignment guide with the visualization necessary for anatomical correlation without need for either navigational support or fluoroscopic guidance. It is widely accepted that the abduction angle of the acetabular component should be in the 35°-to-55° range for proper hip function. The results reported in this study—72 of 74 hips (97.3%) were in the safe zone—are substantially better than results with standard approaches and are comparable to those with approaches using navigational assistance. Results were not affected by BMI.

There is some question about the actual safe zone. It has been defined as 40° by Lewinnek and colleagues[8] and 45° by other authors.[15] In the present study, a safe zone of 45°±10° is used. The mechanical guide and the preoperative templating were designed to achieve 45° of inclination. The 10° range of acceptance allows for 55° being an acceptable outcome. A recent study, however, showed that a cup angle of even 55° showed significantly higher steady-state wear than a cup placed at 45°.[16] This implies that the initial recommendation of 40° by Lewinnek and colleagues[8] should be the goal.

Surgeons should not rely solely on alignment guides when implanting acetabular components. Being able to easily identify bony landmarks is essential in improving the precision of the mechanical guide. The percutaneous guide used in this technique provides an unobstructed view of the bony landmarks and, therefore, more accuracy in cup placement. This new soft-tissue sparing approach has been reproducible for a surgeon who is not involved in the development of the instruments or the approach.

Author's Disclosure Statement

The author reports no actual or potential conflict of interest in relation to this article.

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